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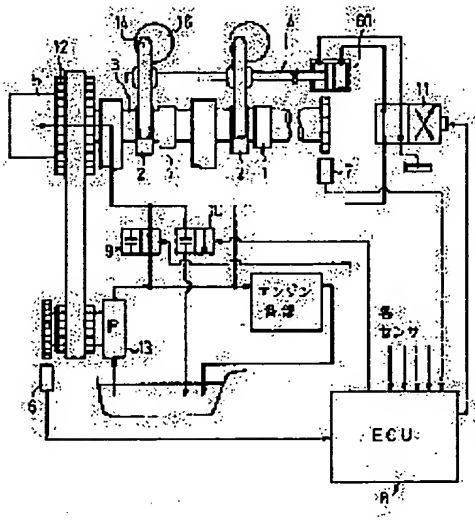
(54) VALVE TIMING REGULATING DEVICE FOR INTERNAL COMBUSTION ENGINE



(57)Abstract:
PURPOSE: To achieve improvement of output and a fuel consumption for a valve timing regulating device by reducing a pumping loss at the time of low rotation speed with a light load and contriving optimum valve timing in a wide range of operation.
CONSTITUTION: A device 5 varying a phase of a cam shaft 3 of an intake valve relative to a crankshaft is provided, the cam shaft 3 is provided with a cam 1 and cam 2 which are changed over by moving a rocker arm 14 with a hydraulic cylinder 60. The cam 2 of which valve opening period is shorter than that of the cam 1 has a cam profile of a large valve lift. Intake valve closing timing is delayed by using the cam 1 to reduce a pumping loss at the time of low revolution speed with a light load. The valve closing timing is advanced with increase of the load, but in the case that the revolution speed is lower than a specific value, a changeover from the cam 1 to the cam 2 is made to lessen valve overlap when the valve closing timing is lead-angled from a fixed value.

CLAIMS

[Claim(s)]

[Claim 1] Have a means to change the clausilium stage of an inlet valve, carry out the lag of the inhalation-of-air valve-closing valve timing at the time of an engine low load, and the pumping loss of a gas column is reduced. In the valve timing adjustment of the internal combustion engine does the tooth lead angle of the inhalation-of-air valve-closing valve timing, and it was made to raise the inhalation-of-air volumetric efficiency of a gas column with increase of a load A means to shorten the valve-opening period of an inlet valve while holding the valve lift of an inlet valve at least more than an EQC is established. The valve timing adjustment of the internal combustion engine with which inhalation-of-air valve-closing valve timing is characterized by shortening an inhalation-of-air valve-opening valve period under conditions earlier than a predetermined stage lower [an engine rotational frequency] than a predetermined value.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to an internal combustion engine's valve timing adjustment, and relates to the valve timing adjustment of the internal combustion engine which can attain reduction of the pumping loss at the time of low load low rotation, and optimization of the valve timing under a large service condition in a detail.

[0002]

[Description of the Prior Art] In the internal combustion engine which has a throttle valve in an inlet pipe, since a throttle valve is made into an abbreviation close by-pass bulb completely at the time of an engine low load, the pressure of the throttle-valve downstream becomes big negative pressure. For this reason, like the inhalation-of-air line of a gas column, this negative pressure will be resisted; it will operate, excessive loss of power and the so-called pumping loss arise, and the piston has become one of the causes of fuel consumption aggravation.

[0003] In order to reduce this pumping loss, the means which carries out good change of the clausilium stage of an inlet valve is established, and whenever [throttle valve-opening] has an effective method of delaying the clausilium stage of an inlet valve more greatly than the piston bottom dead point like an inhalation-of-air line, holding

greatly at the time of engine low load low rotation. That is, the air once inhaled in the gas column can fluctuate an inhalation air content by performing inhalation-of-air valve-closing valve delay by being breathed out within inhalation of air and changing inhalation-of-air valve-closing valve timing with a piston rise. In this case, whenever [throttle valve-opening] is held greatly, and since the above-mentioned inhalation and the regurgitation are performed with abbreviation atmospheric pressure, its actuation resistance of a piston decreases, and a pumping loss reduces them.

[0004] By the way, when the above-mentioned inhalation-of-air valve-closing valve delay is performed, the amount of new mind of stopping in a gas column increases, so that an inhalation-of-air line is set like the piston rise line after a bottom dead point and closes an inlet valve early. Therefore, an engine load is controllable by changing inhalation-of-air valve-closing valve timing instead of controlling an engine load by throttle opening.

[0005] There are some which were indicated by JP,61-145310,A as an example of this kind of valve timing adjustment. With the equipment of this official report, the end of the cam shaft for an inlet-valve drive was equipped with the cylinder-like phase control member through the helical spline, and the timing pulley is further attached in the outside of a phase control member through the helical spline which has torsion of the above and hard flow. If a timing pulley is driven with a belt, a chain, etc. from a crankshaft, a cam shaft will rotate synchronizing with a crankshaft by engagement of the helical spline between a timing pulley, a phase control member and a phase control member, and a cam shaft. Moreover, if said phase control member is moved in the direction of a cam-shaft axis, a cam shaft and a timing pulley will rotate to hard flow mutually to a skid phase control member in accordance with the tooth trace, respectively, got into gear to the helical spline between phase control members. Therefore, it becomes possible to change, while operating the valve timing of an inlet valve, and the clausilium stage of an inlet valve can be set as arbitration at the time of low load low rotation.

[0006] When changing the phase of a cam shaft as mentioned above and performing clausilium stage control of an inlet valve, the valve-opening period of an inlet valve itself does not change. For this reason, when the tooth lead angle of the inhalation-of-air valve-closing valve timing is carried out and it goes with increase of a load, the tooth lead angle also of the inhalation-of-air valve-opening valve timing will be carried out to coincidence. Therefore, if a tooth lead angle is performed more than a certain include angle, the problem on which the bulb overlap with an inlet valve and an exhaust valve increases will arise. if bulb overlap increases at the time of low rotation -- exhaust gas -- blowing -- and also inhalation-of-air volumetric efficiency falls -- internal EGR Increase etc. arises and the problem on which a fall and combustion condition of an output get worse arises.

[0007] With the equipment of said JP,61-145310,A, this problem is solved by changing

the valve-opening period of an inlet valve. That is, as an inlet valve is pushed using a rocker arm from a cam shaft, he is trying to make the lever which established the tooth back as for which the rocker arm carried out curve formation in rocking freedom carry out supporting-point contact with the equipment of this official report. Since the contact location of a lever and a rocker arm changes and the supporting-point location of a rocker arm changes by making a lever rock, the valve-opening period of an inlet valve can be changed. In case the tooth lead angle of the inhalation-of-air valve-closing valve timing is carried out, it is prevented by using the above-mentioned equipment and shortening an inhalation-of-air valve-opening valve period that bulb overlap becomes excessive.

[0008] Another valve timing adjustment is indicated by JP,1-134013,A. Although the equipment of this official report is also changing the rotation phase of a timing pulley and a cam shaft using the same means as above-mentioned JP,61-145310,A, accommodation of the valve-opening period of an inlet valve is performed by different approach. That is, he is trying to press the piston for an inlet-valve drive by the cam of a cam shaft without a rocker arm with the equipment of this official report. This piston is prepared in the end of an oil pressure room, and the piston which pushes an inlet valve is prepared in the oil pressure room other end. If the piston for a drive is pushed by the cam, the piston of the other end will also be pushed through the oil it was [oil] full of the oil pressure room, and an inlet valve will open. With the equipment of this official report, the relief valve which extracts the pressure of this oil pressure room is prepared, and the valve-opening period of an inlet valve is adjusted by controlling the timing which misses oil pressure. That is, the valve-opening period of an inlet valve is shortened, so that the relief valve after push initiation of an inlet valve is opened early. It is possible to make small bulb overlap at the time of low rotation like the equipment of said JP,61-145310,A by this.

[0009]

[Problem(s) to be Solved by the Invention] However, the problem on which a valve lift also decreases arises at the same time it has set on the above-mentioned conventional technique and a gap also shortens the valve-opening period of an inlet valve. That is, since the valve-opening period is shortened by the equipment of JP,1-134013,A of the cam profile of a cam shaft being also fixed, and making it the equipment of JP,61-145310,A also make valve-opening actuation perform using a part of cam profile, a valve lift will also decrease to coincidence.

[0010] However, since compaction of the valve-opening period of an inlet valve is performed with increase of a load, with the above-mentioned conventional technique, a result to which both a valve-opening period and a valve lift decrease has been brought to only the part by which the valve-opening period was shortened having to enlarge a valve lift, and having to secure an inhalation air content essentially. For this reason, with the above-mentioned conventional technique, there is a possibility that the

problem from which an inhalation air content falls at the time of a heavy load, and sufficient output is not obtained may arise. This invention aims at offering the valve timing adjustment of the internal combustion engine which can solve the above-mentioned technical problem and can aim at both reduction of the pumping loss at the time of a low load, and the output reservation at the time of a heavy load.

[0011]

[Means for Solving the Problem] According to this invention, have a means to change the clausilium stage of an inlet valve, carry out the lag of the inhalation-of-air valve-closing valve timing at the time of an engine low load, and the pumping loss of a gas column is reduced. In the valve timing adjustment of the internal combustion engine does the tooth lead angle of the inhalation-of-air valve-closing valve timing, and it was made to raise the inhalation-of-air volumetric efficiency of a gas column with increase of a load A means to shorten the valve-opening period of an inlet valve while holding the valve lift of an inlet valve at least more than an EQC is established. The valve timing adjustment of the internal combustion engine with which inhalation-of-air valve-closing valve timing is characterized by shortening an inhalation-of-air valve-opening valve period under conditions earlier than a predetermined stage lower [an engine rotational frequency] than a predetermined value is offered.

[0012]

[Function] At the time of a low rotation low load, an inhalation-of-air line is delayed more sharply [inhalation-of-air valve-closing valve timing] than a bottom dead point location, and reduction of a pumping loss is achieved. The inspired air volume which the tooth lead angle of the inhalation-of-air valve-closing valve timing is carried out with increase of a load, and is inhaled by the gas column increases. However, since it is rash also in inhalation-of-air valve-opening valve timing with the tooth lead angle of inhalation-of-air valve timing and the bulb overlap with an exhaust valve increases, inhalation-of-air volumetric efficiency falls in the time of engine low rotation.

[0013] In order to prevent this, below with a predetermined value (low rotation), when a tooth lead angle is beyond a predetermined value, it shortens the valve-opening period of an inlet valve, and an engine rotational frequency lessens overlap. However, in this case, a valve lift is held so that it may become more than an EQC or it, and it prevents the inspired-air-volume reduction by compaction of a valve-opening period. Moreover, in high rotation heavy load operation, there is the extrusion effectiveness by exhaust air pulsation, and since volumetric efficiency of the one where bulb overlap is larger improves, an engine rotational frequency does not perform compaction of an inhalation-of-air valve-opening valve period above a predetermined value.

[0014]

[Example] The configuration of the example of the valve timing adjustment of this invention is shown in drawing 1 . In this example, the same equipment as what was indicated by JP,61-279713,A as a lag control unit 5 of an inlet valve is used, and the

phase between the timing pulley 12 and a cam shaft 3 is changed.
[0015] Moreover, in order to change only the valve-opening period of an inlet valve, without changing a valve lift, in this example, two kinds of cams 1 and 2 are formed in the cam shaft 3 for every inlet valve, and the valve-opening period of an inlet valve is changed by moving a rocker arm 14 in parallel with a cam shaft 3, and making it engage with a cam 1 or a cam 2. The cam change-over device of this method is indicated by JP,57-179314,A. In this example, the cam 1 has the cam profile which lengthens an inhalation-of-air valve-opening valve period, and the cam 2 has a profile which shortens a valve-opening period.
[0016] Drawing 2 shows the valve-opening property of the inlet valve by each cam 1 and 2, and the property according [I] to a cam 1 and II show the property by the cam 2. A cam 1 and a cam 2 are arranged so that the clausilium stage of an inlet valve may be in agreement, and the cam profile is set up so that it may become larger than the case where the valve lift by the cam 2 is based on a cam 1. The crank angle sensor by which that 6 showed to drawing 1 detects a crank phase, and 7 are cam angle sensors which detect a cam shaft phase.
[0017] In this example, the lubricant pump 13 of a crankshaft drive is formed, and while supplying a lubricating oil to engine each part, pressure oil is supplied to the oil hydraulic cylinder 60 of the inlet-valve lag control unit 5 and the migration device of a rocker arm 14 through the oil pressure change-over valves (OSV) 9-11.
[0018] Moreover, what 8 shows is an electronic control (ECU) which performs basic control, such as fuel injection, ignition timing control, etc. of an engine. ECU8 consists of digital computers and is performing valve timing control of this invention in addition to the basic control of the above-mentioned engine. For this purpose The output of the crank angle sensor 6 and the cam angle sensor 7 is inputted into ECU8, and also the parameter required for basic control, such as an engine inhalation air content and cooling water temperature, has inputted from various sensors (not shown). Again ECU8 It connects through the drive circuit which is not illustrated to the actuator of OSV 9-11. The change-over of OSV9-OSV11 is controlled.
[0019] Drawing 3 is the sectional view showing the structure of the inlet-valve lag control unit 5 of above-mentioned JP,61-279713,A used by this example. The sleeve which 21 is fixed to a cam shaft 3 by this alignment in drawing, and is rotated to one, cylindrical shape housing which 23 rotates to the timing pulley 12 and one, and 25 are cylinder-like pistons. As for the piston 25, helical spline 29a has geared with helical spline 29b by which the helical splines 27a and 29a were formed in the peripheral face and inner skin again at sleeve 21 peripheral face with helical spline 27b in which it is formed in, respectively and helical spline 27a was formed at housing 23 inner skin, respectively. Therefore, rotation of the timing pulley 12 is transmitted to a cam shaft 3 through housing 23, Splines 27b and 27a, a piston 25, Splines 29a and 29b, and a sleeve 21, and rotates the timing pulley 12 and a cam shaft 3 to one.

[0020] This oil pressure room 31 minds the oil pressure path 33 formed in a cam shaft by forming the annular oil pressure room 31 between the axis end side edge side of the cylindrical piston 25, and housing 23, and it is the oil pressure change-over valve of drawing 1 . It connects with OSV9 and OSV10. OSV9 controls the supply of an oil in the oil pressure room 31 from an oil pump 13 -- OSV10 is controlling discharge of the oil from the oil pressure room 31 to a drain. Moreover, what 35 shows to drawing 3 is compression spring which carries out press energization of the piston 25 at the oil pressure room 31 side.

[0021] OSV9 is made open (ON). It is close (OFF) about OSV10. If it carries out, it is the pressure oil from a pump 13. The oil pressure room 31 is supplied through OSV9 and the oil pressure path 33, and a piston 25 moves rightward [of drawing], compressing a spring 35. If a piston 25 moves to shaft orientations, in order to rotate housing 23 and a sleeve 21 relatively in accordance with the tooth trace of helical spline 27a, b, and 29a and b to a piston 25, respectively, the phase of a pulley 12 and a cam shaft 3 will change. In this condition OSV9 It is OFF in both OSV(s)10. If it carries out, since the location of a piston 25 is held uniformly, a predetermined phase will be maintained. Again It is OFF about OSV9. Carried out as. If OSV10 is turned ON, a piston 25 will be pushed on compression spring 35, and will move leftward [of drawing], and the oil in the oil pressure room 31 It is discharged through OSV10. It follows. It is by ECU8 based on the output of the crank angle sensor 6 and the cam angle sensor 7. Desired inhalation-of-air valve-closing valve timing can be obtained by carrying out change-over control of OSV9 and OSV10.

[0022] Next, the cam change-over device of this example is shown in drawing 4 . This device is the same configuration as what was indicated by JP,57-179314,A, and 41 is the rocker shaft of the hollow installed in parallel with a cam shaft 3 in drawing. The rocker arm 14 is attached in the rocker shaft 41 through the bush 43. The bush 43 is attached possible [rotation and sliding of shaft orientations] to the rocker shaft 41. A rocker arm 14 is equipped with the cam follower 45 which ****s to a cam 1 or 2, with rotation of cams 1 and 2, it rocks the circumference of a rocker shaft 41, and presses the valve lifter 16 of an inlet valve by the other end side, and an inlet valve is opened and closed.

[0023] In the rocker shaft 41, the shaft 49 which can slide on shaft orientations is inserted in. The pin 51 is being fixed to the bush 43, and the tip can touch shaft 49 peripheral surface, and can slide on a pin 51 at shaft orientations. Moreover, it is equipped with compression spring 55a and 55b, respectively between Rings 53a and 53b and the pins 51 which were fixed to the shaft 49 by the both-sides part of the pin 51 of a shaft 49. That is, when a shaft 49 moves to the longitudinal direction of drawing, the motion is transmitted to a pin 51 through compression spring 55a or 55b, and makes it move along with the axis of a rocker shaft 41 in a bush 43.

[0024] What was shown in drawing by 57 is ratchet equipment which positions a bush 43, presses a shot to rocker shaft 41 peripheral face with the spring prepared in the

interior of a bush, and has structure which the periphery slot established in the peripheral face predetermined location is made to carry out fitting, and is positioned. The periphery slot for positioning of a ratchet 57 is established in two places, the location where a cam follower 45 ****s for a cam 1, and the location which ****s for a cam 2. The oil hydraulic cylinder 60 is formed in the end of a shaft 49, and a shaft 49 is moved by introducing pressure oil into the oil pressure rooms 60a and 60b of piston 61 both sides connected with the shaft 49. Oil pressure rooms 60a and 60b It connects with OSV11. Change installation of the oil pressure can be carried out now by change-over of OSV11 at 60a or 60b.

[0025] Since it is positioned by the ratchet 57 after migration initiation for the time being if it is switched from OSV11 and a shaft 49 moves to one side now, a bush 43 does not move. Therefore, spring 55a or 55b will be compressed between a pin 51, ring 53a, or 53b. A shaft 49 continues migration, if the thrust by this compression spring becomes larger than the holding power of a ratchet 57, the shot of a ratchet 57 will separate from one periphery slot, and a bush 43 is pushed on the force of a spring and moves quickly to other periphery slot locations for ratchets. Therefore, a rocker arm 14 moves to another side from one side of cams 1 and 2 in an instant, and a cam change-over completes it immediately. (The insurance device (not shown) it is made for a rocker arm 14 not to move in addition only on the base circle in which cams 1 and 2 are common even if a ratchet 57 separates is established.)

[0026] Next, a valve timing setup of this example is explained using drawing 5 . Drawing 5 shows the valve lift (axis of ordinate) and valve timing of an exhaust valve (EX) and an inlet valve (IN). The curve A of drawing 5 shows the valve timing of the inlet valve at the time of a low load. In order that the rocker arm 14 (drawing 4) may engage with the cam 1 at the time of a low load and the lag adjustment 5 (drawing 1) may delay the closing motion timing of an inlet valve, an inlet valve opens from the middle like an inhalation-of-air line, and after it becomes a compression stroke anaphase after a bottom dead point (BDC), it is closed.

[0027] Drawing 5 Ta The inhalation-of-air valve-closing valve timing at this time (crank angle) is shown. therefore -- this condition -- BDC from -- Ta up to -- although the inhalation of air once inhaled in the gas column is made to flow backwards in a stroke (drawing 5 , Section I) within inhalation of air, since inspired air volume can be adjusted without this performing an inhalation-of-air diaphragm, a pumping loss is reduced. next, the curve B of drawing 5 -- this condition to a load -- increasing -- inhalation-of-air valve-closing valve timing -- Tc up to -- the condition of having carried out the tooth lead angle is shown.

[0028] Air content which flows backwards within inhalation of air as a result of a clausilium stage's carrying out a tooth lead angle (drawing 5 , section II) In order to decrease, the inspired air volume which remains in a gas column increases, and an output increases. However, in this condition, the overlap field with an exhaust valve is

also expanded by the tooth lead angle of an inlet valve, and, in the case of (drawing 5 , Section III), and low r.p.m. operation, it is internal EGR. The fall of combustion instability or an output arises according to increase. For this reason, for an engine rotational frequency, at this example, inhalation-of-air valve-closing valve timing is the predetermined value Tc below in a predetermined value. When a tooth lead angle is carried out, the change-over for a cam 2 from a cam 1 is performed, and it changes into the inhalation-of-air valve-opening valve characteristic of Curve C. By switching to the property of Curve C, an inhalation-of-air valve-opening valve period is shortened, and can decrease bulb overlap (drawing 5 , section IV). . Thereby, the improvement in an output at the time of low r.p.m. operation and reservation of combustion stability can be aimed at. In addition, under the conditions of a high rotation heavy load, since the one where bulb overlap is larger is desirable, a change-over for a cam 2 is not performed.

[0029] To next, drawing 6 The flow chart of the example of the valve timing control action of this invention by ECU8 is shown. This routine is performed as an iterative routine for every (every [for example,] 16 mses) fixed time amount. if a routine starts in drawing 6 -- step 100 **** -- the clausilium stage (crank angle) T of engine-speed N, an engine load, and the present inlet valve is computed. The output of the crank angle sensor 6 to the clausilium stage T is computed for engine-speed N here, respectively from the output of the crank angle sensor 6 and the cam angle sensor 7. Moreover, as a parameter showing an engine load, inhalation air content Q/N per engine 1 rotation is used.

[0030] Next, step 105 The relation of drawing 7 is then used from engine load Q/N, and it is the target clausilium stage To of an inlet valve. It computes. If drawing 7 is referred to, it is the target clausilium stage To. It is a tooth-lead-angle setup (To is smallness) as a delay setup is carried out by the super-low load (the crank angle To is size) and a load increases. It is carried out. next, step 110 **** -- a current engine speed -- predetermined value Nc whether it is low judges -- having -- case an engine speed is high -- (N>=Nc) step 125 progressing -- OSV11 is switched, a cam 1 is chosen and compaction of a valve-opening stage is not performed. It is because the fall of an output will not be produced even if a load increases and overlap increases if an engine is high rotation. engine-speed N -- Nc case it is low -- a degree -- step 115 the current clausilium stage T -- predetermined value Tc The following (Tc tooth lead angle side) ****** -- judging -- Tc if it is a lag side -- step 125 progressing -- a cam 1 -- choosing -- Tc if it is a tooth-lead-angle side -- step 120 progressing -- OSV11 is switched and a cam 2 is chosen. subsequently, step 130 from -- step 140 performing -- step 105 a target clausilium stage comes -- as -- OSV9 and OSV10 are operated and a routine is ended.

[0031] In addition, although this example showed an example about the device in which valve-opening period compaction of the lag control unit of an inlet valve and an inlet valve is performed, these equipments and a device are not necessarily limited to the

thing of the form shown by this example. Two inlet valves which the thing of various forms was changed when not accompanied by reduction in a valve lift especially as a device for valve-opening period compaction, for example, shifted the valve-opening stage slightly can be used, the device in which one valve is stopped or operated can be established, and the device in which a valve-opening period is shortened without decreasing a valve lift as a whole can be adopted.

[0032]

[Effect of the Invention] According to this invention, by having shortened the inhalation-of-air valve-opening valve period with the engine which performs inhalation-of-air valve-closing valve timing delay at the time of low rotation low load driving, without being accompanied by reduction in a valve lift at the time of a low rotation heavy load, loss of power can be prevented and improvement in fuel consumption and increase of an output can be acquired by the large operating range.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the sketch showing the example of the valve timing adjustment of this invention.

[Drawing 2] It is drawing which explains a property whenever [inhalation-of-air valve-opening / of the example of drawing 1].

[Drawing 3] It is the sectional view showing the inlet-valve lag control unit used for the example of drawing 1 .

[Drawing 4] It is the sketch sectional view showing the cam change-over device in which it uses for the example of drawing 1 .

[Drawing 5] It is drawing explaining valve timing control of the example of drawing 1 .

[Drawing 6] It is the flow chart which shows the example of the control action of the valve timing adjustment of this invention.

[Drawing 7] It is drawing showing the relation of the engine load and inhalation-of-air valve-closing valve timing in the example of drawing 6 .

[Description of Notations]

1 2 -- Cam

3 -- Cam shaft

5 -- Inlet-valve lag control unit

6 -- Crank angle sensor

7 -- Cam angle sensor

8 -- Electronic control (ECU)

9, 10, 11 -- Oil pressure change-over valve (OSV)

12 -- Timing pulley
13 -- Oil pump
14 -- Rocker arm
16 -- Valve lifter

[Translation done.]